

FORM PTO-1390 (REV 11-2000)	U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTORNEY'S DOCKET NUMBER 36-1470
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		U.S. APPLICATION NO. (If known, see 37 C.F.R. 1.5) 09/914262 Unknown
INTERNATIONAL APPLICATION NO. PCT/GB00/01052	INTERNATIONAL FILING DATE 21 March 2000	PRIORITY DATE CLAIMED 24 March 1999

TITLE OF INVENTION

HANDWRITING RECOGNITION SYSTEM

APPLICANT(S) FOR DO/EO/US

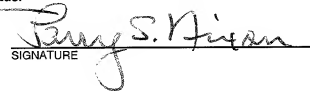
MILNER

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. ☒ The U.S. has been elected by the expiration of 19 months from the priority date (Article 31).
5. A copy of the International Application as filed (35 U.S.C. 371(c)(2)).
 - a. ☒ is attached hereto (required only if not communicated by the International Bureau).
 - b. ☒ has been communicated by the International Bureau.
 - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
 - a. ☐ is attached hereto.
 - b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
 - a. ☐ are attached hereto (required only if not communicated by the International Bureau).
 - b. ☐ have been communicated by the International Bureau.
 - c. ☐ have not been made; however, the time limit for making such amendments has **NOT** expired.
 - d. ☐ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ A English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 To 20 below concern document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 C.F.R. 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 C.F.R. 3.28 and 3.31 is included.
13. ☒ A **FIRST** preliminary amendment.
14. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
15. ☐ A substitute specification.
16. ☐ A change of power of attorney and/or address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821-1.825.
18. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. ☒ Other items or information. PTO-1449 and copy of International Search Report

U.S. APPLICATION NO. (if known, see 37 C.F.R. 1.51) 09/914262	INTERNATIONAL APPLICATION NO. PCT/GB00/01052	ATTORNEY'S DOCKET NUMBER 36-1470	
21. <input checked="" type="checkbox"/> The following fees are submitted:		CALCULATIONS PTO USE ONLY	
BASIC NATIONAL FEE (37 C.F.R. 1.492(a)(1)-(5)): -- Neither international preliminary examination fee (37 C.F.R. 1.482) nor international search fee (37 C.F.R. 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO\$1000.00 -- International preliminary examination fee (37 C.F.R. 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO\$860.00 -- International preliminary examination fee (37 C.F.R. 1.482) not paid to USPTO but international search fee (37 C.F.R. 1.445(a)(2)) paid to USPTO\$710.00 -- International preliminary examination fee (37 C.F.R. 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4)\$690.00 -- International preliminary examination fee (37 C.F.R. 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4)\$100.00			
ENTER APPROPRIATE BASIC FEE AMOUNT =		\$ 860.00	
Surcharge of \$130.00 for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 C.F.R. 1.492(e)).		\$ 0.00	
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE
Total Claims	4	-20 = 0	X \$18.00
Independent Claims	2	-3 = 0	X \$80.00
MULTIPLE DEPENDENT CLAIMS(S) (if applicable)			\$270.00
TOTAL OF ABOVE CALCULATIONS =			\$ 860.00
<input type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.			0.00
SUBTOTAL =			\$ 860.00
Processing fee of \$130.00, for furnishing the English Translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 C.F.R. 1.492(f)).			0.00
TOTAL NATIONAL FEE =			\$ 860.00
Fee for recording the enclosed assignment (37 C.F.R. 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 C.F.R. 3.28, 3.31). \$40.00 per property			40.00
Fee for Petition to Revive Unintentionally Abandoned Application (\$1240.00 - Small Entity = \$620.00)			0.00
TOTAL FEES ENCLOSED =			\$ 900.00
			Amount to be: refunded \$
			Charged \$
a. <input checked="" type="checkbox"/> A check in the amount of \$900.00 to cover the above fees is enclosed. b. <input type="checkbox"/> Please charge my Deposit Account No. 14-1140 in the amount of \$_____ to cover the above fees. A duplicate copy of this form is enclosed. c. <input checked="" type="checkbox"/> The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 14-1140. A duplicate copy of this form is enclosed. d. <input checked="" type="checkbox"/> The entire content of the foreign application(s), referred to in this application is/are hereby incorporated by reference in this application.			
NOTE: Where an appropriate time limit under 37 C.F.R. 1.494 or 1.495 has not been met, a petition to revive (37 C.F.R. 1.137(a) or (b)) must be filed and granted to restore the application to pending status.			
SEND ALL CORRESPONDENCE TO: NIXON & VANDERHYE P.C. 1100 North Glebe Road, 8 th Floor Arlington, Virginia 22201-4714 Telephone: (703) 816-4000			
 SIGNATURE			
Larry S. Nixon NAME			
25,640 REGISTRATION NUMBER			August 24, 2001 Date

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of

MILNERAtty. Ref.: **36-1470**Serial No. **Unknown**

Group:

National Phase of: **PCT/GB00/01052**International Filing Date: **21 March 2000**Filed: **August 24, 2001**

Examiner:

For: **HANDWRITING RECOGNITION SYSTEM**

* * * * *

August 24, 2001Assistant Commissioner for Patents
Washington, DC 20231

Sir:

PRELIMINARY AMENDMENT

Prior to calculation of the filing fee and in order to place the above identified application in better condition for examination, please amend the claims as follows:

IN THE CLAIMS

Please substitute the following amended claims for corresponding claims previously presented. A copy of the amended claims showing current revisions is attached.

3. (Amended) A handwriting recognition system as claimed in claim 1, in which the sampling means, filtering means and classifier are implemented in a digital computer environment.

MILNER
Serial No. **Unknown**

REMARKS

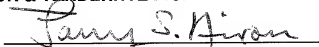
Attached hereto is a marked-up version of the changes made to the claims by the current amendment. The attached page is captioned "**Version with markings to show changes made.**"

The above amendments are made to place the claims in a more traditional format.

Respectfully submitted,

NIXON & VANDERHYE P.C.

By:



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Reg. No. 25,640

LSN:Imy

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MILNER

Serial No. **Unknown**

VERSION WITH MARKINGS TO SHOW CHANGES MADE

3. (Amended) A handwriting recognition system as claimed in claim 1 [or claim 2], in which the sampling means, filtering means and classifier are implemented in a digital computer environment.

5/pats

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HANDWRITING RECOGNITION SYSTEM

The present invention relates to a handwriting recognition system and more particularly to a hardware and an algorithm for implementing such a system.

- 5 In PCT application number GB98/0316 (Publication No. WO99/22338) there is disclosed a portable computer in the form of a pen-type casing. Incorporated within the casing is at least one accelerometer which is used to detect movement of the pen with respect to its environment. By using the instrument for handwriting it is possible to effect data entry or transmission of signals reflecting movement, the user
- 10 using either a pen tip mounted switch or a finger operated switch to indicate that movement is effecting a written input.

- There are many other pen-type input devices on the market in addition to stylus scroll pallets typically used in so-called palm top computers where handwriting recognition has been used. Such devices often require very precise movement which
- 15 may not reflect natural handwriting movements for the user. One of the problems which makes characteristic handwriting recognition difficult is that while the underlying movement made by an individual to represent a particular letter may be consistent an element reflecting user movements due to stress and other factors will be present.

- 20 According to the present invention there is provided a handwriting recognition system comprising means responsive to input analogue signals representative of movement of a handheld writing device, sampling means to provide signals representative of the acceleration of the writing device in at least x axis and y axis channels at a predetermined capture sampling rate, and filtering means to
- 25 remove dc level components and to provide smoothing of the output whereby signals representative of movement of the pen over a period are supplied to a classifier for comparison with a template representative of characters formed.

- The classifier may use hidden Markov modelling (HMM) techniques using a large number of states to determine the character defined by movement. The system
- 30 may include an input indicative of a user's intention that the movement is representative of character writing.

According to a feature of the present there is provided a method of analysing signals from a moving handheld device, the method comprising sampling signals at a

predetermined rate, passing signals through a bandpass filter to remove dc level and excess acceleration components, sampling the filtered output to provide a series of vectors representing the position of the handheld device at periodic intervals and using a classifier to compare the sample sets with predetermined templates to

5 determine the character for output.

A handwriting recognition system in according with the invention will now be described by way of example only with reference to the accompanying drawing of which:

Figure 1 is a block schematic diagram of the system;

10 Figure 2 shows relative positioning of the x and y axis of the handwriting device of Figure 1;

Figure 3 is a schematic diagram of the handheld writing device of Figure 1 in a particular position;

Figure 4 shows relative input and output vector streams from the system of
15 Figure 1; and

Figures 5 to 9 show comparative templates for a number of different letters.

Referring first to Figure 1, an input device 1 such as a stylus produces x and y vector streams 2 and 3 which are fed into a sampling unit 4. The outputs x and y are generally from accelerometers or other position sensing devices within the stylus

20 1. Also feeding the sampling unit 4 is an output 5 from a switch indicated here as being in the nib section of the stylus 1 such that contact between the switch 6 and a surface is indicative of the stylus being used in a writing mode. It will be appreciated that the nib switch 6 when incorporated in a non-surface contacting stylus, such as that disclosed in the previously referred PCT application, may be replaced by a user

25 operable switch.

The output of the sampling unit 4, which samples the incoming streams at 60 Hz for example, is passed to a bandpass filter arrangement 7 and thence to a down sampling unit 8 which produces digitised vectors x and y over a period of time. The x and y vectors are passed to a classifier 9, which uses a hidden Markov model

30 to carry out a comparison between the vectors and templates representing written characters. The classifier 9 may be arranged to output to a visual display 10.

More specifically, the stylus 1 for example comprises a simple plastic casing containing the electronics for transferring information to a PC. Two accelerometers

mounted in the stylus, for example, are used to produce the x and y outputs. The nib switch is a simple on/off switch connected to determine when pressure is being applied to the pen nib and can therefore detect when a pen for stylus 1 is writing.

Turning briefly to Figure 2, the two accelerometers mounted in the top of the pen measure acceleration across their plane such that effectively they measure acceleration along the x axis 11 and the y axis 12 of the writing surface 14. The acceleration measured by the sensors is made up of two components, acceleration due to gravity and the acceleration as a result of stylus movement. It will be appreciated that the acceleration due to gravity is always present, such that when the pen is exactly horizontal both sensors would measure acceleration of $1g$. As the angle of the pen to the horizontal changes (as shown for example in Figure 3), the accelerometers are subject to $\sin \theta \times 1g$ where θ is the inclination angle of the stylus 1.

The other component, acceleration as a result of the pen moving is produced by the acceleration and deceleration effect as the user writes.

The acceleration of the two sensors x_{total} and y_{total} can be expressed as

$$y_{\text{total}} = y_g + y_{\text{movement}} \text{ and } x_{\text{total}} = x_g + x_{\text{movement}}$$

The remaining items of Figure 1 are incorporated in a computer unit, for example a PC, and three signals, as previously indicated, 2, 3 and 5 being the two acceleration signals and binary signal from the pen switch are provided to the PC.

In one embodiment the two acceleration signals are read into a normal PC using an RS232 port and the binary switch signal by means of the games port of a sound card.

The sampling section must sample sufficiently regularly to capture the movement of the pen but should not over-sample, which would result in a waste of processing and storage within the PC. It has been found satisfactory for the purposes of the current invention to sample at a rate of 60 Hz. The acceleration signals for each channel are read in as two byte words giving a dynamic range for each acceleration signal from 0 to 65535. The pen nib switch is similarly sampled at the same rate.

As previously mentioned, the accelerometer signals are partly dependent on a component of the earth's gravitation field passing through the accelerometer of the stylus 1. This results in an almost constant dc level present on the output corresponding to the average pen angle θ while writing. The bandpass filter 7 is thus arranged to filter the signals from the two accelerometers to remove the offsets. Additionally, the bandpass filter smoothes the output from the sensors thus correcting for instability introduced by the user so that the smoothed output from the sensors increases robustness and facilitates matching between the x and y vectors and stored templates.

Turning now to Figure 4, for each sample received on the PC from the accelerometers, the pen nib switch (or manually operable switch) indicates whether the stylus 1 was being used in a writing mode or not. The down sampling process 8 uses the information to down sample acceleration samples and to retain only those when it was known that the stylus 1 was writing. Thus, consider Figure 4, assuming that the x axis and y axis vectors are as shown at 15 and 16, then the down sampling vectors need only be taken into account when the nib switch signal indicator 17 is high. This will reduce the number of samples significantly so that the output from the down sampling process is a time series of two dimensional vectors x and y as indicated at 18 and 19.

Having completed processing of the acceleration measurement from the stylus 1 the vector stream is passed to the classifier stage 9 which takes in a series of vectors representing the acceleration measurements made within a given word. These are then compared to a set of templates which cover the range of words within the system vocabulary and the word which matches most closely with the unknown input word is deemed the recognised word. In this system the classifier is a hidden Markov model. Such models have been widely used in speech recognition and using a large number of states in the hidden Markov model will give the best performance for corresponding handwriting recognition.

The display 10, which displays the output from the PC allows display of a word, for example, on a screen.

While the above handwriting recognition system is intended for use with a series of known words which, depending on the system vocabulary entered into the PC, may be a large number, it will be possible to use the same kind of system to

validate single character entry. Using single character recognition and using cursive entry it is still possible to build individual words which may not be present in the vocabulary. There may be a lower level of confidence in words created rather than template determined. However, over time, the vocabulary may be expanded where multiple entries of the same word have occurred such that higher confidence levels may be achieved.

A typical single accelerometer output can be seen respectively for the letters c, b, f and h in Figures 5 to 8. In each case the template developed here shows three entries on a single accelerometer for each of the letters.

- 10 In Figure 9, f, b, h and c are shown in comparison so that a suitable template for comparison may be derived. It will be appreciated that the combination of an x accelerometer trace and a y accelerometer trace will serve further to emphasise the difference between each input letter.

- Bandpass filtering in digital form to remove dc components and high frequency components increases the reliability of the recognition process and therefore the reliability of the interpretation of the stylus input 1. It will be appreciated that where the stylus 1 carries other components, for example an internal processing arrangement, some of the functions may be transferred from the PC to the stylus 1. All of the components of sampling, bandpass filtering, down sampling and
- 20 classifying can be implemented in a suitable computer program.

CLAIMS

1. A handwriting recognition system comprising:
means responsive to input analogue signals representative of movement of a
5 handheld writing device;
sampling means to provide signals representative of the acceleration of the
writing device in at least x axis and y axis channels at a predetermined capture
sampling rate; and
filtering means to remove dc level components and to provide smoothing of
10 the output whereby signals representative of movement of the pen over a period are
supplied to a classifier for comparison with a template representative of characters
formed.
2. A handwriting recognition system as claimed in claim 1, in which the
15 classifier uses a hidden Markov model for comparison purposes.
3. A handwriting recognition system as claimed in claim 1 or claim 2, in which
the sampling means, filtering means and classifier are implemented in a digital
computer environment.
- 20 4. A method of analysing signals from a moving handheld device, the method
comprising sampling signals at a predetermined rate, passing signals through a
bandpass filter to remove dc level and excess acceleration components, sampling the
filtered output to provide a series of vectors representing the position of the handheld
25 device at periodic intervals and using a classifier to compare the sample sets with
predetermined templates to determine the character for output.

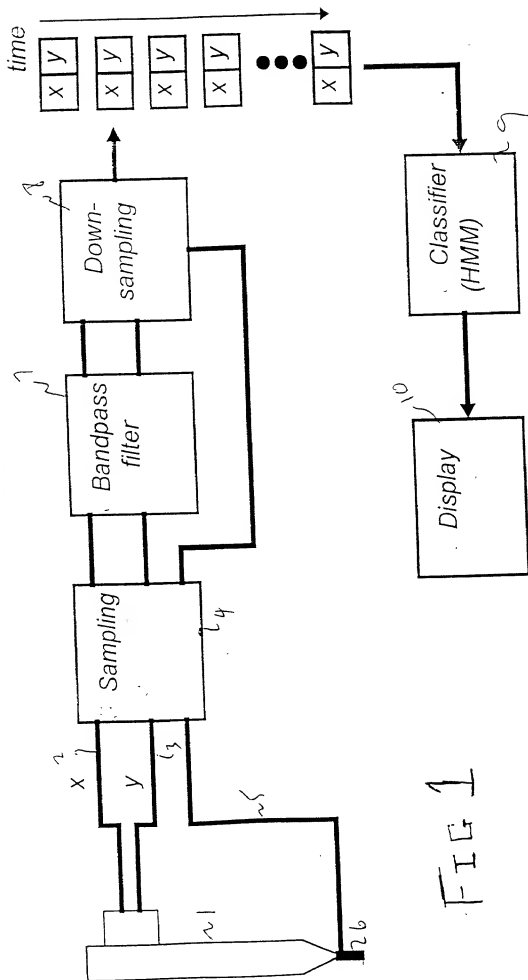
ABSTRACT
HANDWRITING RECOGNITION SYSTEM

In order to improve the accuracy of recognition of hand-written input using a
5 stylus (1), output signals from a plurality of accelerometers representing x and y axis
acceleration and deceleration are sampled at a predetermined rate and passed through
a digital bandpass filter (7) to remove high frequency components and dc components
arising from gravity. x and y vectors derived from the original x and y input signals
are passed to a classifier using a hidden Markov model. Bandpass filtering improves
10 the robustness of the interpretation of the vectors against stored templates which
may be templates of individual characterisations or of whole words.

Figure 1

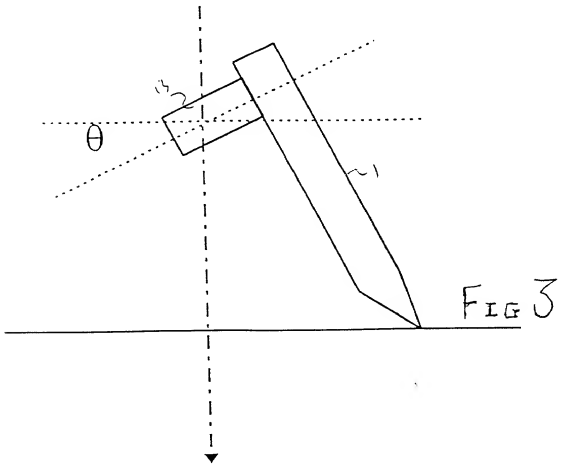
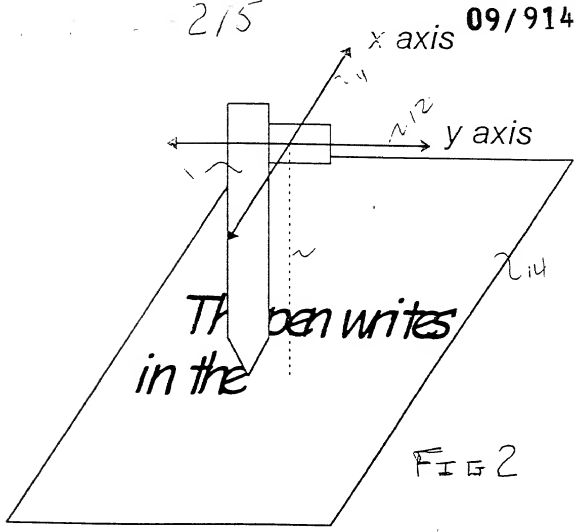
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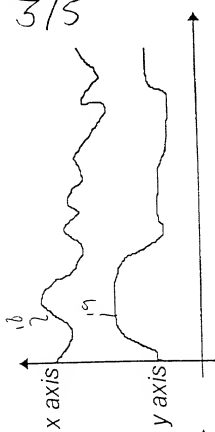
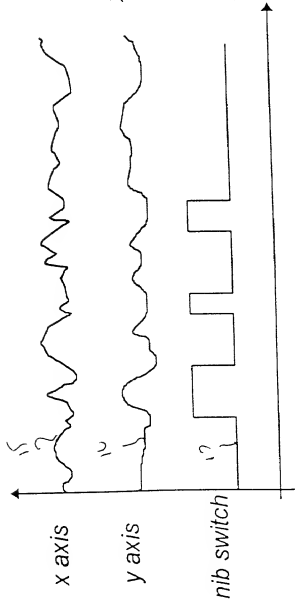


FIG 4

Fig. 5

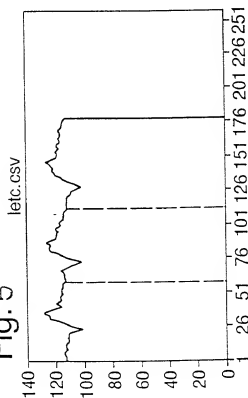


Fig. 6

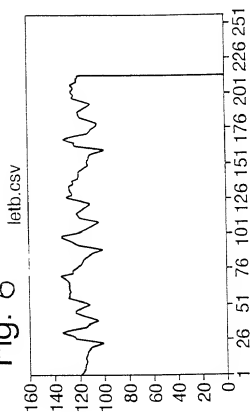


Fig. 7

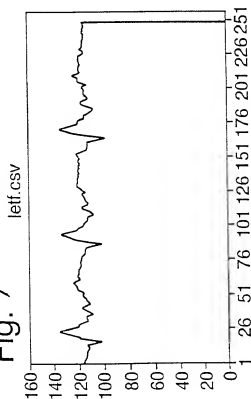


Fig. 8

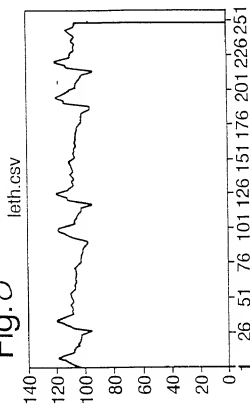
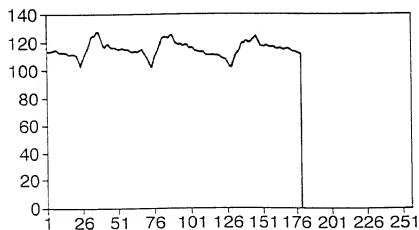
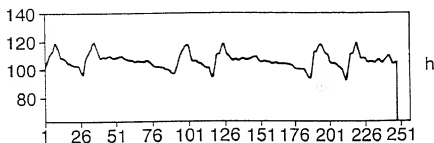
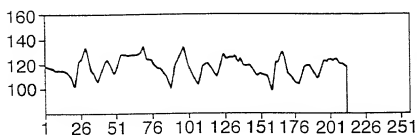
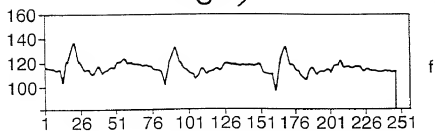


Fig. 9



0914262.002101

Nixon & Vanderhye P.C. (10/99)
(Domestic Non-Assigned/Foreign)

**RULE 63 (37 C.F.R. 1.63)
DECLARATION AND POWER OF ATTORNEY
FOR PATENT APPLICATION
IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

As a below named inventor, I hereby declare that my residence, post office address and citizenship are as stated below next to my name, and I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

HANDWRITING RECOGNITION SYSTEM

the specification of which (check applicable box(es)):

is attached hereto
was filed on

as U.S. Application Serial No.

(Atty Dkt. No.)

☒ was filed as PCT International application No.
and (if applicable to U.S. or PCT application) was amended on

PCT/GB00/01052

on 21 March 2000

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above. I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with 37 C.F.R. 1.56. I hereby claim foreign priority benefits under 35 U.S.C. 119/365 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed or, if no priority is claimed, before the filing date of this application:

Priority Foreign Application(s):

Application Number
9530270.6Country
EUROPEDay/Month/Year Filed
24 March 1999

I hereby claim the benefit under 35 U.S.C. §119(e) of any United States provisional application(s) listed below.

Application Number

Date/Month/Year Filed

I hereby claim the benefit under 35 U.S.C. 120/365 of all prior United States and PCT international applications listed above or below and, insofar as the subject matter of each of the claims of this application is not disclosed in such prior applications in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose material information as defined in 37 C.F.R. 1.56 which occurred between the filing date of the prior applications and the national or PCT international filing date of this application:

Prior U.S./PCT Application(s):

Application Serial No.

Day/Month/Year Filed

Status: patented
pending, abandoned

PCT/GB00/01052

21 March 2000

PENDING

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon. And on behalf of the owner(s) hereof, I hereby appoint **NIXON & VANDERHYE P.C., 1100 North Glebe Rd., 8th Floor, Arlington, VA 22201-4714, telephone number (703) 816-4000 (to whom all communications are to be directed),** and the following attorneys (hereof (if the same address) individually and collectively owners'/owners' attorneys to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith and with the resulting patent: Arthur R. Crawford, 25327; Larry S. Nixon, 25640; Robert A. Vanderhye, 27046; James T. Hosmer, 30184; Robert W. Faris, 31352; Richard G. Basha, 22770; Mark E. Nusbaum, 32348; Michael J. Keenan, 32106; Bryan H. Davidson, 30251; Stanley C. Spooner, 27393; Leonard C. Mitchard, 29009; Duane M. Byers, 33363; Jeffrey H. Nelson, 30481; John R. Lastova, 33149; H. Warren Burnam, Jr., 29366; Thomas E. Byrne, 32205; Mary J. Wilson, 32955; J. Scott Davidson, 33489; Alan M. Kagen, 36128; Robert A. Molan, 29834; B. J. Sadoff, 36663; James D. Berquist, 34776; Updeep S. Gill, 37334; Michael J. Shea, 34725; Donald L. Jackson, 41090; Michelle N. Lester, 32331; Frank P. Presta, 19828; Joseph S. Presta, 35329. I also authorize Nixon & Vanderhye to delete any attorney names/numbers no longer with the firm and to act and rely solely on instructions directly communicated from the person, assignee, attorney, firm, or other organization sending instructions to Nixon & Vanderhye on behalf of the owner(s).

Inventor's Signature: Ben MilnerDate: 29-3-00

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(Zip Code)

NR7 9LJ

2.

Inventor's Signature:

Date:

Inventor:

(first)

Mi

(last)

(citizenship)

Residence: (city)

Post Office Address:

(Zip Code)

FOR ADDITIONAL INVENTORS, check box ☐ and attach sheet with same information and signature and date for each.